Sustainable Transit Leadership Project: Final Report

San Francisco Bay Area Rapid Transit District (BART) &
U.S. EPA Region 9

EPA Grant ID No. X1-97942001

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Introduction

San Francisco Bay Area Rapid Transit (BART) owns and operates an automated high-speed rail transit system and a wide range of supporting facilities. BART serves San Francisco, Oakland, and the Bay Area's many diverse municipalities. BART is one of the largest transit authorities in the nation and one of the most prominent inter-city authorities in the world. Transit provides tremendous environmental benefits by reducing automobile emissions and the impacts of growth. BART has over 100 million riders per year and without BART more than 64 million of them would have to drive alone or lose their mobility.

In 2002, BART received a grant to work with the U.S. Environmental Protection Agency Region 9 Office of Pollution Prevention and Solid Waste to develop, implement, and document short and long-term sustainable transit design, procurement, and construction practices. The grant was awarded under a national 2002 OSWER Innovations Pilot. The work plan, entitled "Sustainable Transit Leadership Project," and the Amendment work plan outlined six specific objectives:

- Assess opportunities for BART innovations
- Implement short range energy efficiency pilot project
- Redevelop BART Facilities Standards to promote sustainability
- Share project information to promote public awareness and replication
- Transfer Innovations Pilot Findings
- Quantify Environmental Benefits and Costs of Sustainable Transit Practices

This report documents training, planning document revisions, new products and equipment substitutions, conference publications, and presentations that were prepared during the achievement of the above objectives. This report also provides an overview of project results, lessons learned, and opportunities for additional measurement.

A bulk of this work was prepared under EPA Grant ID No. X1-97942001-0 and Amendment No. X1-97942001-1.

Summary Results

Measures implemented under the Sustainable Transit Leadership Project, including the BART Facility Standards (BFS) adoption and energy efficiency pilot, have lead to the adoption of multiple sustainability practices throughout BART's planning, construction, and operations. These practices have allowed for and increase in certain valuable resources and design strategies, and a significant decrease in resource consumption. Table 1 summarizes the impact of the BFS and the energy efficiency pilot on key resources.

Table 1 - Summary of Impacts of BART projects on several key resources. Source: BART contract drawings, interviews with BART project managers and engineers, various project submittals, and contractors.

Resource	Quantity	Units
Bike parking spaces	530	spaces
Pedestrian walkways, bike paths, or access improvements	10	projects
Bus passenger shelters	14	shelters
Erosion/Sedimentation control strategies implemented	12	projects
Storm water collection/treatment systems	7	projects
Cool roof materials	74,500	sq. ft
Projects with high efficiency irrigation systems	6	projects
Potable water saved by recycling at washing facilities	876,000	gallons
Fly ash used to replace cement	1,805	tons
Clean agent fire suppression systems	22	projects
Low VOC paint use	17	projects
Waste diverted from landfill	6,450	tons
Tipping fees avoided[1]	$ 645,000	$
Energy savings from relamping and energy saver[2]	955,190	kWh/yr
Energy cost savings from relamping and energy saver	$ 66,863	$/yr
Greenhouse gas reductions from electricity savings[3]	471	tCO2e

Data in this summary table was collected from BART projects with contracts written since the BFS adoption in 2004 to attempt to quantify the impacts of the BFS. Data was gathered from contractor submittals, project drawings, and interviews with project managers, resident engineers, and contractors.

The summary results are not exhaustive; there are many BART contracts for which detailed project information was not located during the survey of contracts conducted under this grant. Greater detail on the sources of the data above is provided in the section of this report on Transit Leadership Project Results.

The remainder of this document outlines the objectives and tasks carried out under this grant.

[1] Based on a disposal rate of $100 per ton for concrete, asphalt, brick, mixed dirt and concrete debris charged at the Davis Street Recycling and Transfer Station, Waste Management, 2007.

[2] Data was only logged by the energy saver during the first year of operation. The above figure assumes the energy saver achieved the level of energy savings in subsequent years.

[3] Based on the California (WECC) marginal grid intensity factor of 0.493 metric tons of CO_2 per MWh, http://climatetrust.org/solicitations_2007_Electricity.php#map

Assess opportunities for BART innovations

Tasks

Task 1: Research green design and technology information from leading sustainable design authorities, including the U.S. Green Building Council, U.S. EPA, U.S. Department of Energy, Rocky Mountain Institute, state and local government models and green building case studies.
Task 2: Research current green transit practices.
Task 3: Assess current status of sustainable practices at BART, begin documenting appropriate baseline information, and develop short (6 month) and longer (2-5 years) opportunities to develop and implement sustainable transit practices. Target areas will include construction and demolition debris, sustainable building materials (recycled content, low VOC, less toxic, etc.), energy efficiency, and station recycling capacity.
Task 4: Contact potential program partners and provide project information to develop additional project expertise. Potential partners include the U.S. Department of Energy, California Integrated Waste Management Board, Alameda County Waste Management Authority and the U.S. Green Building Council.

Deliverables

- List of reference documents, web sites, and contacts used in background sustainable design research
- List of reference documents, web sites, and contacts for green transit projects
- List of short and long range sustainable transit opportunities
- List of project partners, areas of expertise, and planned involvement

The deliverables associated with Objective: Assess opportunities for BART innovations are included in Appendix 1-4.

Implement Short-Range Energy Efficiency Pilot Project

Tasks

Task 1: Select short-range energy efficiency technology opportunities based on available baseline energy usage data available, technology installation time and costs, and energy conservation, and anticipated application at BART and other transit authorities.
Task 2: Establish measurement plan for tracking effectiveness, specifically covering energy usage and cost savings.
Task 3: Install energy efficiency pilot equipment.
Task 4: Monitor energy use of new equipment.
Task 5: If significant energy/cost savings are achieved develop plan to install and monitor additional equipment.
Task 6: If the pilot is successful, the findings will be publicized.

Deliverables

- Information on technology selected for pilot
- Outline of monitoring plan for the pilot

- Equipment cost, installation costs, and “lessons learned” during installation and initial use period
- Energy and cost monitoring results showing data from before and after the new equipment was installed
- Plan for installation and monitoring of additional equipment
- Copies of any press releases and press coverage received

The deliverables associated with Objective: Implement short-range energy efficiency pilot project are included in Appendix 5-10.

Redevelop BART Facilities Standards to promote sustainability

Tasks

Task 1: Review BART Facilities Standard documents, including Design Guidelines, Facilities Criteria, Standard Plans, and Standard Specifications to prioritize opportunities to incorporate sustainable building guidance.
Task 2: Assess opportunities for measurement of Sustainable Facilities Standard.
Task 3: Develop and draft language in appropriate documents targeting the following priorities and opportunities that arise during the project:

Initial discussion held with EPA regarding solid waste products and paint expert.

A. Construction and Demolition Debris Management
B. Sustainable Building Materials incorporating the purchase of EPA-designated recycled content products as required by the Resource Conservation and Recovery Act section 6002, and to the extend practical other environmentally preferable purchasing criteria (i.e., low VOC, indoor air quality, less toxic, locally produced materials, low embodied energy, recyclability, etc.).
C. Recycling/waste management space allowing for extensive, efficient recycling opportunities.

Task 4: Provide training to appropriate BART staff on sustainable design and building materials opportunities and solicit feedback.
Task 5: Promote adoption of new sustainable transit language in BART Facilities Standard.
Task 6: Track and monitor implementation results as appropriate and develop additional tools needed as appropriate (vendor lists of jobsite recyclers or building materials, training on the installation of new materials, etc.).

Deliverables

- Assessment of BART Facilities Standard revision priorities
- Draft specification revisions
- BART staff training materials
- Actual BFS changes
- List of measurement opportunities and future measurement opportunities
- Project results and any additional materials developed

Deliverables associated with Objective: Redevelop BART Facilities Standards to promote sustainability are included in Appendix 11-15. Project results are included in the section of this report under the objective "Quantify Environmental Benefits and Costs of Sustainable Transit Practices."

Share project information to promote public awareness and replication

Tasks

Task 1: Develop a presentation of project process, results, and lessons learned for project partners to give at conferences and meetings.
Task 2: Provide electronic files of BART Facilities Standard revisions and project "Lessons Learned Summary" to other transit authorities.
Task 3: Raise public awareness of BART sustainable building and recycling practices through posters and press releases.

Deliverables

- Any presentations developed with information regarding number of attendees
- List of distribution networks used to get project information to other transit authorities
- Copies of any posters, press, or print materials

The deliverables associated with Objective: Share project information to promote public awareness and replication are included in Appendix 16-18.

Transfer Innovations Pilot Findings

Tasks

Task 1: Identify at least two appropriate Region 9 organizations to share pilot project findings, possible targets include Golden Gate Transit District and City of Phoenix Public Transit Department.
Task 2: Share pilot project findings through meetings, calls, presentations, etc.
Task 3: At the end of the project, contact the organizations to determine results of information used
Task 4: Present pilot information at least one major conference (in addition to original grant commitment)

Deliverables

- List of organizations for collaboration and summary of any changes made as a result
- Name, date, and location of conferences attended with target audience, copy of presentations, and approximate number of people attending sessions.

The deliverables associated with Objective: Transfer innovations pilot findings are included in Appendix 19 and 20.

Quantify Environmental Benefits and Costs of Sustainable Transit Practices

Tasks

Task 1: Research standards and practice of sustainable transit operations at national leaders: BART and the New York Transit Authority (and others as appropriate) to determine the environmental benefits and short and long-term costs/cost savings associated with various sustainable systems that have been implemented.
Task 2: Release report of research findings.
Task 3: When appropriate, review and revise BART Facilities Standards to incorporate the findings.

Deliverables

- Updated BFS
- Measurement of as many results as possible

A summary of the deliverables associated with Objective: Transfer innovations pilot findings are included in Appendix 21 and 22. Further details on the impact of the BFS are outlined in the following section on the measurement project results.

Transit Leadership Project Results – BFS

Every BART construction contract put in place since the 2004 adoption of the BFS has incorporated the principles of sustainability built into the BFS because these guidelines and requirements are now the organizational standard. Modifications to the BFS are rare and have occurred on an individual project basis only when some aspect of a facility's design warranted a substantial change. This has allowed sustainability principles to be incorporated into hundreds of millions of dollars of capital improvements and to enter into the consciousness of engineers throughout BART.

Scope of BART's Capital Programs

BART is one of the largest light rail transit agencies in the United States, conveying almost 340,000 passengers (on average) each weekday.[4] It consists of 104 miles of track on 7 lines, serving four counties in Northern California. BART owns and operates 43 stations and a variety of other facilities. Each year, BART spends roughly $1 billion on new construction, renovations, and maintenance.

Over seventy contracts have been executed since the development of new BFS under the Sustainability Policy in 2004. These contracts represent a wide variety of projects from traction motor repair to station relamping to pedestrian bridge installation to new station and line construction. It is difficult to quantify the total impact that the new BFS standards have had due to this variation in project type and sustainability considerations. However Table 2 demonstrates the systematic nature of the Common Requirements for Environmental Design and

[4] In fiscal year 2007. Source: BART, 2007. http://bart.gov/docs/station_exits_FY.pdf.

Sustainability. At least one sustainability principle was applied to every project listed via sustainability guidelines built into BFS because each project involved elements for which sustainability practices were built as standards.

Table 2 – BART contracts since 2004 with at least one identified sustainability element. Each "X" indicates a project element that was a consideration in the design or construction of each project. This is not an exhaustive list of BART contracts since 2004; however it is illustrative of the wide variety of project types and broad applicability of sustainability practices built into the BFS.

	SUSTAINABILITY ELEMENTS																		
	Site Optimization					Water Conservation				Energy Efficiency						Const. Materials		IEQ		
Description	SITE SELECTION AND ACCESS	EROSION AND SEDIMENTATION CONTROL	STORM WATER MANAGEMENT	REDUCE HEAT ISLAND EFFECT	REDUCE IMPACT OF NOISE AND VIBRATION	LANDSCAPE IRRIGATION SYSTEMS	PLANT SELECTION	PLUMBING FIXTURES	VEHICLE WASHER	BUILDING CONFIGURATION AND PLACEMENT	EXCEED TITLE 24 ENERGY BUDGET	BUILDING ENVELOPE	BUILDING MECHANICAL SYSTEMS	LIGHTING	TOTAL BUILDING PERFORMANCE	EVALUATION OF MAJOR BUILDING MATERIALS AND ASSEMBLIES	SPECIFY MATERIALS AND CONSTRUCTION PRACTICES	INDOOR AIR QUALITY	LIGHTING AND VIEWS	ACOUSTICAL AND VIBRATION CONTROL
CONCRETE REHABILITATION OF LAKE MERRITT SUBWAY		X	X		X											X	X			
FRUITVALE BICYCLES FACILITY-CLS	X															X	X			
UNION CITY STATION - INTERM	X	X	X	X	X	X	X							X		X	X			
PRELIMINARY ENGINEERING-FREMONT/WSX EXT.	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
SILICON VALLEY EXTENSION-PE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LAFAYETTE STATION SOUTH ENTRANCE IMPROVEMENTS	X	X	X	X	X	X	X									X	X			
PLEASANT HILL PARKING STRUCTURE	X	X	X	X	X									X		X	X	X		
CENTRAL COSTA CROSSOVER	X	X	X													X	X			
CONCORD YARD TRAIN WASHER	X	X	X	X	X				X			X		X		X	X	X	X	
RICHMOND STATION-INTERMODAL (AC TRANSIT)	X	X	X	X	X	X	X							X		X	X			
ROUTE 580 BART BARRIER IMPROVEMENT - PHASE 2																X	X			
WEST DUBLIN-PLEASANTON STATION	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
EAST DUBLIN PARKING	X	X	X	X	X									X		X	X	X		
REPLACEMENT OF STREET LEVEL ELEVATOR ENCLOSURES AT FOUR STATIONS	X	X	X		X											X	X			
GLEN PARK ACCESS IMPROVEMENTS-CTS	X	X	X													X	X			
BALBOA PARK INTERMODAL	X	X	X	X	X	X	X							X		X	X			
ST. CHARLES BRIDGE PEDESTRIAN AND BIKE LINK	X	X	X	X	X											X	X			
SIDEWALK AND RETAINING WALL ADDITION AT THE DALY CITY STATION	X	X	X	X	X											X	X			
SFO BIKE PATH-CLS	X	X	X	X	X											X	X			
RELAMPING FOR FIFTEEN (15) STATIONS														X		X	X		X	
REROOF THREE STATIONS												X				X	X			
REPAVE PARKING LOTS AT THREE STATIONS	X	X	X	X	X											X	X			

Description	SUSTAINABILITY ELEMENTS																				
	Site Optimization					Water Conservation				Energy Efficiency						Const. Materials		IEQ		
	PASSENGER STATION SITE	EROSION AND SEDIMENTATION CONTROL	STORM WATER MANAGEMENT	REDUCE HEAT ISLAND EFFECT	REDUCE IMPACT OF NOISE AND VIBRATION	LANDSCAPE IRRIGATION SYSTEMS	PLANT SELECTION	PLUMBING FIXTURES	VEHICLE WASHER	BUILDING CONFIGURATION AND PLACEMENT	EXCEED TITLE 24 ENERGY BUDGET	BUILDING ENVELOPE	BUILDING MECHANICAL SYSTEMS	LIGHTING	TOTAL BUILDING PERFORMANCE	EVALUATION OF MAJOR BUILDING MATERIALS AND ASSEMBLIES	SPECIFY MATERIALS AND CONSTRUCTION PRACTICES	INDOOR AIR QUALITY	LIGHTING AND VIEWS	ACOUSTICAL AND VIBRATION CONTROL
BREAKROOM REFURBISHMENT AT THREE STATIONS											X	X	X	X	X	X	X	X	X	X
RELAMP PARKING FACILITIES														X		X	X		X	
INSTALLATION OF GUARDRAILS AND PLATFORMS AT AERIAL CROSSOVER STRUCTURES																X	X			
STATION RELAMPING														X		X	X		X	
RE-ROOF STATION CANOPIES				X								X				X	X			
CC COUNTY PLATFORM EDGE																X	X			
RE-ROOF SHOPS/STRUCTURES				X								X				X	X			
STATION RELAMPING AT VARIOUS LOCATIONS														X		X	X		X	
BUILDING AND HAYWARD YARD CONTROL CENTER				X								X				X	X			
OUTDOOR SUBSTATIONS AND GAP BREAKERS REPAINTING - PHASE IV																X	X			
REPLACEMENT OF PLATFORM EDGE TILES - Phase V		X			X											X	X			
RE-ROOF HAYWARD MAIN SHOP				X								X				X	X			
REPAVE FREMONT, SAN LEANDRO AND COLISEUM STATIONS		X	X		X											X	X			
PARKING LIGHTING IMPROVEMENT AT ASHBY, FREMONT AND DALY CITY STATIONS														X		X	X		X	
PARKING LIGHTING IMPROVEMENTS AT ASHBY, FREMONT AND DALY CITY STATIONS														X		X	X		X	
BREAKROOMS: SLS, CDS, CBO AND OCT											X	X	X	X	X	X	X	X	X	X
NEW BREAK ROOM CONSTRUCTION AT SAN LEANDRO AND CONCORD STATIONS; AND BREAK ROOM REMODELING AT PITTSBURG/BAY POINT STATION											X	X	X	X	X	X	X	X	X	X
BREAKROOMS: SHS, BFS, DCS											X	X	X	X	X	X	X	X	X	X
BREAKROOM REFURBISHMENT AT THREE STATIONS											X	X	X	X	X	X	X	X	X	X
LAKE MERRITT BLDG DISMANTLING		X	X		X												X			
ELECTRONIC BIKE LOCKERS	X																			

While comprehensive detailed measurement efforts were outside of the scope of the EPA grant, the impact of the BFS on BART's sustainability can be demonstrated via an assessment of several key sustainability practices implemented on BART projects. These include measures that affect:

- Passenger Station Site
- Erosion and Sedimentation Control
- Storm Water Management
- Heat Island Effect
- Landscaping and Irrigation Systems
- Vehicle Cleaning and Water Recycling
- Materials and Assemblies
- Construction Waste Management
- Station and Site Mechanical
- Electrical Power and Lighting

Summary Impacts

Data was collected from BART projects with contracts written since the BFS adoption in 2004 to attempt to quantify as many impacts of the BFS on the aforementioned resources as possible. Data was gathered from contractor submittals, project drawings, and interviews with project managers, resident engineers, and contractors.

Table 3 highlights various measures implemented and savings achieved as a result of guidelines and requirements embedded in the BFS.

Table 3– Summary of Impacts of BART projects on several key resources. Source: BART contract drawings, interviews with BART project managers and engineers, various project submittals, and contractors.

Resource	Quantity	Units
Bike parking spaces	530	spaces
Pedestrian walkways, bike paths, or access improvements	10	projects
Bus passenger shelters	14	shelters
Erosion/Sedimentation control strategies implemented	12	projects
Storm water collection/treatment systems	7	projects
Cool roof materials	74,500	sq. ft
Projects with high efficiency irrigation systems	6	projects
Potable water saved by recycling at washing facilities	876,000	gallons
Fly ash used to replace cement	1,805	tons
Clean agent fire suppression systems	22	projects
Low VOC paint use	17	projects
Waste diverted from landfill	6,450	tons
Tipping fees avoided[5]	$ 645,000	$
Energy savings from relamping and energy saver	955,190	kWh/yr
Energy cost savings from relamping and energy saver	$ 66,863	$/yr
Greenhouse gas reductions from electricity savings[6]	471	tCO2e

Sources of Summary Results

Data included in Table 3 came from some, but not all, of the contracts BART has executed since the 2004 BFS adoption. These contracts were ones that had already been constructed, or were far enough in the design phase to have detailed project information or drawings.

The summary results are not exhaustive; there are many BART contracts for which detailed project information was not located during the survey of contracts conducted under this grant. Information was gathered from 25 contracts out of the 71 contracts identified as having invoked the BFS (contracts written after the August 2004 BFS adoption).

The projects that fed this summary table included:

- Balboa Park Intermodal
- Break room refurbishment at ten stations
- Central Costa Crossover
- Concord Yard train washer

[5] Based on a disposal rate of $100 per ton for concrete, asphalt, brick, mixed dirt and concrete debris charged at the Davis Street Recycling and Transfer Station, Waste Management, 2007.

[6] Based on the California (WECC) marginal grid intensity factor of 0.493 metric tons of CO_2 per MWh, http://climatetrust.org/solicitations_2007_Electricity.php#map

- East Dublin parking garage
- Electronic bike lockers at nine facilities
- Fruitvale bike parking facility
- Glen Park access improvements
- Lafayette Station south entrance improvement
- Pleasant Hill parking structure
- Reroofing of three stations and Hayward Yard main shop
- Richmond Station Intermodal
- SFO bike path
- Sidewalk and retaining wall addition at the Daly City Station
- St. Charles bridge pedestrian and bike link
- Station relamping at 20 stations and other facilities
- Union City Intermodal
- Warm Springs Station and Extension
- West Dublin/Pleasanton Station and parking garages

The estimates included in the table range in precision. For example, the number of bike parking spaces added to stations since 2004 is a fairly precise number extracted from site plans and interviews with project engineers. Other resource estimates, like tons of waste diverted, are less precise because they are estimated from site plan dimensions or are based on project engineers' or contractors' estimates of volumes of waste hauled from a site.

Regardless of the range of precision found in the estimates of resource savings from above, the summary of the impacts of the BFS on BART's operations demonstrate that many quantifiable benefits have occurred as a result of the sustainability practices built into the BFS.

The following sections provide specific examples of projects on which resource savings were achieved. Once again, the example measures and results given in the following sections are not exhaustive lists of all of the impacts of the BFS. These examples were drawn from only the projects surveyed during the grant; project information was gathered from 25 contracts. The full impact of the sustainability practices built into the BFS extends into projects for which results were not quantified during this report preparation.

Passenger Station Site

Site selection and development are guided at the most general level by principles of sustainability built into the BFS Design Guidelines. The Common Requirements state that BART should select alignment of BART routes and sites for BART stations and other facilities with the following in mind:

- Optimize transit use and access including inter-modal opportunities and Transit Oriented Development (TOD) potential, and
- Follow the principles of environmentally sensitive site selection and development.

At a more detailed level, the Design Criteria for Architecture specify requirements for the design and construction of passenger sites to promote pedestrian access, bicycle use, and safe and

streamlined interconnection with other vehicular modes of transport. Examples of specific criteria built into the BFS include:

- Pedestrian walkways shall be paved and free of tripping hazards,
- Wheelchair curb ramps…shall be provided wherever a pedestrian traffic lane crosses a curb,
- Crosswalks shall be clearly defined and well marked,
- Bicycle paths shall avoid unnecessary curvature or excessively steep grades,
- Bicycle parking shall be located out of pedestrian walkways and within sight of the station agent's booth or near station entrance,
- Racks shall be grouped for a minimum of 20 bicycles,
- The minimum design capacity for any bus or taxi loading zone shall be two vehicles,
- Boarding and off-loading of bus patrons shall be protected from vehicular traffic, and
- Weather protection, including canopies, shall be provided for passengers from the bus stop to the station entrance point.

These measures improve the ease with which transit riders can access BART from other modes of transportation. This serves to increase the appeal of riding public transit, as well as to increase the appeal of using alternatives to personal vehicles to access public transit.

Projects that have invoked some or all of these practices of TOD and multi-modal passenger site access built into BFS include:

- Union City Station Intermodal –improved bus access, a pedestrian tunnel, and bike rack installation
- West Dublin-Pleasanton Station
- Contra Cost County Crossover –preservation of a pedestrian/bike path
- Lafayette Station south entrance improvements –installation of a new bike ramp and handrail on the entrance stairs
- St. Charles Bridge and pedestrian bike link - improved pedestrian and bike access to the Daly City Station
- Sidewalk and retaining wall addition at the Daly City Station –improved pedestrian access to the Station
- Fruitvale bicycle parking facility –attended bike parking for up to 250 bicycles
- Warm Springs Station and line extension –preservation of a community park, preservation of an existing telecommunications easement for future bike path development, pedestrian and bike paths to the station entrance, bike parking, and convenient bus and carpool access.
- Richmond Station Intermodal
- Glen Park access improvements –enhanced pedestrian and wheelchair access
- Balboa Park Intermodal
- SFO bike path
- Electronic bike locker installation (supplementing or replacing existing parking) at the following stations:
    - North Berkeley – 48 bike storage lockers
    - Ashby – 12 bike storage lockers

- Rockridge – 32 bike storage lockers
- Macarthur – 38 bike storage lockers
- West Oakland – 6 bike storage lockers
- Lake Merritt – 56 bike storage lockers
- San Leandro – 20 bike storage lockers
- Bay Fair – 16 bike storage lockers
- East Dublin/Pleasanton – 12 bike storage lockers

Some of the quantifiable results of these measures include:

- An additional 530 bike parking spaces at 13 stations[7],
- Ten new or enhanced bike or pedestrian paths built at station areas, and
- Fourteen new bus passenger shelters.

It was not possible to quantify the total impact that the guidelines for passenger station site have had on sustainability within BART because the most important impact of these measures may be the enhanced passenger experience provided by improved Intermodal opportunities. The indicators above, however, show a tangible benefit to passenger station site environment and access as a result of the BFS.

Erosion and Sedimentation Control

Common Requirements dictate that temporary and permanent erosion and sediment control measures shall control erosion to reduce negative impacts on water and air quality to:

- Prevent loss of soil during construction by storm water runoff and/or wind erosion
- Prevent sedimentation of storm sewer or receiving streams
- Prevent polluting the air with dust and particulate matter.

More specifically Section 01 57 00 of the BFS requires that the contractor shall:

- Prevent erosion and control runoff sediment by diverting storm runoff or by retaining sediment delivered by storm runoff,
- Control construction operations so that excessive sediment or silt shall not be introduced into the drainage systems,
- Protect stockpiled earth materials, open excavations, trenches, and similar with barriers to prevent erosion,
- Provide dust control at all times,
- Comply with all applicable laws concerning prevention, control, and abatement of water pollution, and
- Prepare and submit an Erosion and Sediment Control Plan that documents design and construction details and locations of all proposed temporary control structures.

All construction projects involving site work are required to include measures for erosion and sedimentation control. Specific, notable control strategies that have been used include:

[7] The estimate for bike parking spaces is based on the requirement that new bike racks are grouped for a capacity of 20 bikes or more. The minimum of 20 bikes is assumed at the stations which are still in design phase and for which an official count is not yet available.

- Abandonment of old, fiberglass reinforced plastic (non-toxic) sumps underground to prevent air and noise pollution caused by their excavation,
- Installation of sediment control bags on storm drains at construction sites,
- Construction of concrete washout containment areas and concrete washout recovery, and
- Installation of fiber rolls around project perimeters to prevent loose soil runoff.

At least 13 projects have implemented erosion and sedimentation control measures during construction since the adoption of the BFS, however quantifying the impact of these measures on sediment loading to local water systems was outside of the scope of this grant.

Storm Water Management

Site erosion and runoff is not exclusively a concern during construction. Storm water runoff in the built environment has an adverse impact on natural drainage systems. The Common Requirements address this concern by requiring that BART projects limit disruption and pollution of natural water flows by managing storm water runoff. More specifically this is achieved by:

- Providing oil/water separator systems to intercept runoff from parking facilities,
- Designing the project site to maintain natural storm water flows by promoting infiltration,
- Include storm water detention areas to promote infiltration,
- Consider pervious paving, garden roofs, and storm water collection for non-potable uses.

Projects that have involved storm water management strategies include:

- Warm Springs Station which will incorporate bioswale systems in the parking lots to collect and filter storm water runoff and rainwater collection systems on the roof,
- Union City Intermodal which will involve an underground storm water treatment system that will remove oil and other contaminants from storm water before it enters the city storm drain,
- Concord Car Wash which is capturing storm water runoff from the roof of the car wash facility and using it to displace potable water used for car washing.

At least 7 projects have implemented storm water control and treatment measures since the adoption of the BFS, however quantifying the impact of these measures on storm water flows was outside of the scope of this grant.

Heat Island Effect

Heat island is the thermal gradient between developed and undeveloped areas resulting from the high heat capacity of many man-made materials, including concrete, asphalt, and other building materials. Measures in the BFS to reduce the heat island effect include those targeted at non-roof and roof surfaces.

Non-roof measures include requiring that 30% of a site's non-roof impervious surfaces provide shade, use light-colored/high-albedo materials, or use open grid pavement and that a minimum of 50% of parking spaces are placed underground or are covered.

BART addresses the roof based heat island effect by using "cool roofing" materials to both decrease heat gain through roof and to reduce heat island effect. Specifically, the Common

Requirements specify EnergyStar compliant and high emissivity roofing (emissivity of at least 0.9 when test in accordance with ASTM E408).

Projects that have incorporated or will incorporate strategies to reduce the heat island effect include:

- Richmond Yard S&I Building
- Hayward Yard Control Center
- West Dublin-Pleasanton Station and Parking Garage
- East Dublin Parking
- Pleasant Hill Parking
- Warm Springs Station
- Union City Intermodal

Non roof heat island effects have been addressed on recent BART projects including the construction of multiple story parking garages, in which all but the top level and perimeter spaces are shaded (well over 50% of parking) and the incorporation of shade trees in paved areas at new stations (e.g. Warm Springs).

A specific, more easily quantified example is a strategy geared towards roof heat island effects. The re-roofing project at the Hayward Yard involved over 62,000 square feet of modified bitumen roofing with an EnergyStar qualified top coat was installed on the existing metal roof of the Hayward Yard Main Shop. The top coat, a rubber membrane that covers and protects the bitumen roofing, is manufactured by GAF Materials Corporation. In addition to meeting EnergyStar requirements, it also met cool roof rating council requirements for solar reflectance and thermal emissance.

Landscaping and Irrigation Systems

There are very few sanitary fixtures in any of BART's facilities so some of the biggest opportunities for efficient water use lie in site landscaping and irrigation system design.

The Common Requirements specify that BART shall design and operate water efficient irrigation systems, and make plant selections in accordance with water conservation principles. Specific requirements and implementation strategies are given in BFS Design Criteria for Landscaping and Vegetation Control, and BFS Section 32 84 00 Planting Irrigation System.

The Architectural Criteria for Landscaping require that:

- At least 75% of plant materials are drought resistant,
- Shade trees are used when possible to reduce non-roof heat island effect,
- Irrigation systems conform to local code,
- Non-potable water is used where available,
- The system shall be designed for minimum runoff and overspray onto non-irrigated areas,
- All irrigation systems shall be equipped with a controller capable of dual or multiple programming and be controlled by a central computer,
- Every controller shall have an irrigation schedule based on time of year, pant material, solids, etc.,

- Contract documents shall include a water budget, and
- Several other control and design criteria to minimize water use by landscaping.

Section 32 84 00 of the BFS specifies details of the landscaping irrigation system design and construction. Some of the most important design requirements with respect to water efficiency include the use of moisture sensors, design for minimal blockage, overspray, and runoff, and central controls and scheduling.

Recent or current BART projects that have landscaping and irrigation systems include:

- West Dublin-Pleasanton Station
- Warm Springs Station
- Union City Intermodal
- Richmond Station Intermodal
- Balboa Park Intermodal
- Lafayette Station Entrance Improvements

All of these projects were required to incorporate the water efficient design strategies specified in Section 32 84 00, allowing BART to reduce the demand for potable water for irrigation use at a minimum of 6 BART facilities. Quantifying the volume of water saved relative to what would be used by less efficient systems was outside of the scope of this grant.

Vehicle Cleaning and Water Recycling

Another water conservation strategy built into the Common Requirements is to minimize vehicle washer water usage. Specific details to implement this strategy are found within the Architecture Criteria for Yards and Shops which state that:

- Exterior Vehicle Cleaning will take place at automated, mechanical washers consisting of rotating trackside brushes.
- The washers shall be designed to recycle water within the car wash to minimize water use and quantity or wastewater produced.

Vehicle washing facilities have been built at the following yards:

- Concord Yard
- Hayward Yard
- Daly City Yard
- Richmond Yard

The design of the Concord Yard Train Car Washing Facility included several measures to capture and reuse car-washing water, and to reduce the overall demand for water as well. A scanner powered by BARTnet ensures that vehicles are only washed when necessary. A sensor to ensure that water is only sprayed when a car has entered the facility controls sprayers. Splash shields were installed around sprayers and brushes to prevent overspray. Finally, a concrete slab with a drainage system was extended for an additional 130 feet from the car wash exit so runoff from the trains is captured and added to the recycled water storage for reuse.

All of these measures lead to a normal recovery rate of about 40%. The Concord facility is designed to wash 200 train cars per day. It requires approximately 30 gallons of water to wash one car and roughly 12 gallons of this demand can be met with recycled water. This will allow BART to reduce the amount of clean, potable water used to wash train cars by approximately 876,000 gallons per year when at full operation. During times of drought, the facility can recycle up to 70% of the wash. The filters in the recycling systems more rapidly deteriorate when recycling this much water so the car washes are only operated under drought mode during severe droughts. In a drought year, which may happen every 7 years, water recycling can save roughly an additional 330,000 gallons of clean water.[8]

The car washing facility built at the Concord Yard was the only one built after the 2004 BFS. Therefore the water savings from the Concord Yard water recycling practices are the only ones directly attributable to the BFS requirement even though all four Yards use similar strategies to reclaim about 40% of train car washing water. The water conservation design strategies, now institutionalized by the BFS, save BART much more water as the savings achieved at the Concord Yard alone. In total, water recycling at BART train washing facilities saves on the order of 1.6 million gallons of clean water each year.[9]

Materials and Assemblies

The Common Requirements list 8 major facility material categories for which sustainability guidelines are provided. These include:

- Concrete
- Roofing
- Heating, Ventilation, and Air Conditioning (HVAC) Equipment
- Fire Suppression Systems
- Adhesives and Sealants for Interiors
- Paints
- Flooring
- Toilet Partitions

Portland Cement Concrete

Portland cement is the most commonly used cement. Its manufacture involves heating various raw materials, most commonly limestone, to over 1400 degrees Fahrenheit. As such its production requires a significant amount of energy. Fly ash is a glass like powder produced from coal fired power generation that can be mixed with lime and water to form a compound similar to Portland cement. Because it is a byproduct of another industry (power production) its use drastically reduces the amount of energy required to produce concrete relative to the use of Portland cement. Fly ash can also improve the strength, segregation, and ease of pumping of concrete, and can, therefore, serve as a cost effective and safe replacement for Portland cement in certain concrete applications.[10]

[8] Assuming that the facility operates in drought mode, saving an additional 9 gallons per car, for 6 months during a drought year.
[9] Based on average car volumes at Hayward, Daly City, and Richmond Yards of 1740, 2164, and 1518 cars per month respectively. BART, 2007.
[10] U.S. DOT, 2007. Fly Ash. http://www.fhwa.dot.gov/infrastructure/materialsgrp/flyash.htm

The Common Requirements specify that BART shall:

- Utilize fly ash as a replacement for a portion of the Portland cement in concrete,
- Utilize High Volume Fly Ash Concrete (HVFAC) in cast-in-place concrete to the greatest extent practical, and
- Utilize fly ash and ground slag to the greatest extent practical in concrete mixes for pre-cast items.

BFS Section 03 05 15 provides technical guidance on concrete mix designs for a variety of applications including the requirements that:

- Concrete mix designs will produce concrete suited for proper placement and finishing,
- Mix design for HVFAC shall include replacement of 25-50% of Portland cement by weight with fly ash,
- Mix design for subway structures and below-grade retaining walls for stations and other facilities shall include 15% replacement of the cement with fly ash,
- Mix design for architectural concrete and formed concrete which will be exposed to the public in the finished work shall include 10% replacement of the cement with fly ash,
- Mix designs for mass concrete shall have a percentage of fly ash replacement of cement by weight that shall be approved by the Engineer.

Concrete is a major element in many BART projects including:

- Concrete rehabilitation of Lake Merritt Subway
- Central Costa Crossover
- Route 580 BART barrier improvement
- Replacement of street level elevator enclosures at Civic Center, Embarcadero, Montgomery Street, and Powell Street Stations
- Repave Fremont, San Leandro, and Coliseum Stations
- Union City Station intermodal
- West Dublin-Pleasanton Station and Parking Garages
- St. Charles Bridge
- Sidewalk and retaining wall addition at the Daly City Station
- East Dublin Parking Garage
- Pleasant Hill Parking Garage

The best example of fly ash use in BART projects are the four parking garages currently under construction – East Dublin, West Dublin and West Pleasanton (both located at the site of the new West Dublin/Pleasanton Station), and Pleasant Hill – whose designs involved significant amounts of fly ash to replace Portland cement. All of the architectural concrete used in the garages contains 10% fly ash by weight, as per the BFS.

The two West Dublin-Pleasanton garages, built to house approximately 1200 vehicles total, involved the use of approximately 20,000 cubic yards of concrete, about 8,000 cubic yards of which was used in the deck and contained no fly ash due to the quick curing period required. The remainder of the concrete (12,000 cubic yards) contained 10% fly ash by weight, or

approximately 654 metric tons in total (assuming a fly ash content of 120 pounds per cubic yard). The East Dublin Garage is bigger than the other two – a seven story garage built to house about 1500 vehicles. Its construction involved the use of approximately 19,200 cubic yards of concrete, the architectural portion of which contained 10% fly ash by weight. This led the use of approximately 576 tons of fly ash. The Pleasant Hill Parking Garage was similar design to the East Dublin Garage, and also contained approximately 576 tons of fly ash. In total, 1805 tons of Portland cement was displaced by fly ash in the four parking garages.

Fire Suppression Agents

Fire suppression systems historically utilized HCFCs and Halons, extremely potent ozone depleting substances, as a flame retardant. Alternative fire suppression agents were developed as a result over increasing concern over the hole in the ozone layer of the Earth's atmosphere.

The Common Requirements state that BART shall:

- Select systems that do not contain HCFSCs or Halons, and
- Phase out HCFCs and Halons in existing fire suppression systems when appropriate.

BFS Section 15380 sets specifications for designing, furnishing, installing, and testing clean agent fire suppression systems. The specifications for the fire suppression agent itself state that:

- The agent shall be heptafluoropropane, HFC-227ea, the physical and chemical properties of which shall conform with the requirements of NFPA 2001, and
- The agent shall have the following characteristics:
    - Ozone depletion potential of zero;
    - Atmospheric lifetime less than 50 years, and,
    - 4-hour LC_{50} > 788,696 ppm.

The same section specifies installation and operation guidelines that ensure safe and sustainable handling of the fire suppression agent.

Since 2004, the following projects have included (or will include once constructed) the installation of clean agent fire suppression systems:

- Warm Springs Station
- West Dublin/Pleasanton Station and parking structures,
- Pleasant Hill parking structure,
- East Dublin parking structure, and
- 16 new or refurbished break rooms at BART stations,

A total of 22 projects have fire suppression systems in place (or planned) that will provide for the safety of facility users without compromising the integrity of the atmosphere in the way that Halon or HCFC based systems do.

Paint and Indoor Air Quality

The Common Requirements specifically addresses the volatile organic compound (VOC) content of paints and coatings by requiring that contractors specify paints and coatings with a VOC and chemical component limit set by Green Seal's GS-11 requirements. The GS-11 requirements set

a maximum threshold of VOC concentration and list 12 aromatic compounds that are not to be used as ingredients in paint.

BART BFS Section 09 91 00 includes specifications for all coating systems materials (including primers, emulsions, enamels, stain, sealers, and fillers). The type and minimum percent solids (MPS) is specified for fifteen specific types of coatings to ensure a minimum level of paint quality.

Paint has been an in the following projects since 2004:

- New break rooms for the San Leandro and Concord Stations,
- Break room remodel at Pittsburg/Bay Point Station,
- Refurbish break rooms at south Hayward and Bay Fair Stations,
- West Dublin-Pleasanton Station,
- Warm Springs Station, and
- Fabricating and installing architecturally designed finishes and doors.

The specifications for paint in all of these contracts were based on BFS 09 91 00 which led to improved indoor air quality in at least 17 BART facilities from the use of paint containing low VOCs and none of the aromatic compounds prohibited by Green Seal Standards.

Construction Waste Management

BART BFS Section 01 74 21 includes details regarding project waste management. At a minimum, the requirements for diversion of construction and demolition debris from landfill shall be in no case less than that required by local regulations. Diversion is defined to mean "to use any material for any purpose other than disposal in a landfill or transfer facility."

However, BFS section 01 74 21 sets additional minimum targets that must be met, if they are more stringent than local requirements. These are:

1. Divert a minimum of 70 percent of construction waste from landfill
2. Divert a minimum of 100 percent of steel and concrete demolition waste from landfill and an overall minimum of 50 percent of remaining demolition waste from landfill.

The following projects have produced or will produce some amount of construction and demolition waste:

- Concrete rehabilitation of Lake Merritt Subway,
- Demolition & removal of Irvington Pumping Station,
- Repave Coliseum, Colma, and Rockridge Station parking lots,
- Refurbish or construct break rooms at San Leandro, Concord, Pittsburg/Bay Point, South Hayward, Bay Fair, Macarthur, West Oakland, and Union City Stations,
- Replacement of street level elevator enclosures at Powell St., Montgomery St., Civic Center, and Embarcadero Stations,
- Bay Fair Station TLC,
- Concord Yard Train Car Wash,

- Replacement of platform edge tiles,
- Lake Merritt Building dismantling,
- West Dublin/Pleasanton Station
- Warm Springs Extension and Station,
- East Dublin parking,
- Pleasant Hill parking structure,
- Richmond Station Intermodal,
- Balboa Park Station Intermodal,
- Union City Station Intermodal,
- Glen Park access improvements, and
- Lafayette Station entrance improvements.

The Waste diversion requirements have led to the diversion of significant amounts of waste from landfill. An example project is on the Union City Intermodal project involving the excavation of an existing parking lot in order to construct a new bus circulator roadway, parking lot, and streetscape improvements. The Waste Management Plan submitted by the contractor estimated that 6300 tons of concrete, asphalt, landscape debris, and garbage will be generated by the project. Of this, 5420 tons will be asphalt that will be recovered and sent to a recycler who will grind it and sell it as base material.[11] Several other small projects, including station access improvements and parking lot repaving, produced an additional 1030 tons of asphalt paving to be recovered and recycled that was able to be quantified from project drawings or interviews with project managers.

Electrical Power and Lighting

The common Guidelines for Environmental Design & Sustainability require that projects use energy efficient equipment and controls, i.e. Energy Star products, and incorporate natural lighting to the extent practical.

The criteria for Electrical Design also address light pollution and specify that BART shall meet or provide lower light levels and uniformity ratios than those recommended by the Illuminating Engineering Society of North America (IESNA) Recommended Practice Manual: Lighting for Exterior Environments (RP-33), except that in no case shall light levels be less than that required under the Facilities Criteria. Outside luminaries shall have shading and the maximum candela value of interior and exterior lighting shall not spill out of buildings and property boundaries respectively.

The most detailed lighting and power requirements are found in BFS section 26 50 00 Lighting. This section specifies various electrical components that affect the efficiency of lighting provided at BART facilities, including:

- Ballasts - Ballasts shall be of high efficiency, with high power factor (higher than 0.9) by the use of capacitor. They shall be rapid start or constant wattage autotransformer (CWA) type ballast, depending on the fixture type.
- Lamps:

[11] Top Grade Construction, 2007. Union City Waste Management Plan. Prepared for BART.

    - Fluorescent – Energy efficient T8, rapid start fluorescent lamps with reduced mercury contents compliant with the U.S. EPA Toxic Characteristic Leaching Procedure (TCLP) test.
    - Metal Halide Lamps: clear or coated as indicated suitable for all operating positions.
    - High Pressure Sodium Lamps: clear or coated as indicated suitable for all operating positions.
    - Light-Emitting Diode (LED) Exit Signs: super bright solid state LED lamps.
    - Induction Lamps: either 85 or 150 W, 82 CRI, with transformer for 277 V operation.
- Control Equipment:
    - Photoelectric Sensors shall operate from dusk-to-dawn with adjustments from 2 to 50 foot candles.

In addition to ensuring that all new lamps and fixtures are high efficiency, BART has implemented several major relamping projects since the adoption of the BFS. Retrofits of lighting have occurred at the following stations and facilities:

- Ashby
- Fremont
- Daly City
- Pittsburg/Bay Point
- Lake Merritt
- Coliseum
- Castro Valley
- East Dublin/Pleasanton
- Lafayette
- Walnut Creek
- North Concord/Martinez
- Ashby
- El Cerrito Del Norte
- Richmond
- Embarcadero
- Glen Park
- Balboa Park
- Colma
- Transbay Tube Tunnel
- Wayside Store Building

Many of these retrofits involved replacing multiple lamp types – fluorescent, mercury vapor, metal halide, and high-pressure sodium. The relamping projects served multiple purposes: to reduce mercury exposure risks to BART employees and patrons, to improve light quality at stations and sites, and to reduce energy demand for lighting.

The most easily quantifiable energy savings are those achieved by the replacement of T12 fluorescent lamps and magnetic ballasts with T8 type fluorescent lamps and rapid start electronic ballasts, which provide the same amount of light with much less electricity.

Table 4 shows the approximate annual energy savings generated by all of BART's recent and current relamping contracts. In total, relamping fluorescent lamps throughout BART will save over 500,000 kWh each year, at a cost savings of roughly $36,300 annually.[12] This estimate of electricity savings is based on BART engineers' estimates for the number of lamps of each type (a T8 replaced by a new T8 versus a T12 replaced by a new T8) and the typical hours of operation at each station.

[12] Based on an electricity rate of $0.07 per kWh, BART, 2007.

Table 4– Estimated Annual Energy Savings Achieved by BART Relamping Contracts

	EXISTING					REPLACEMENT					ELECTRICITY
	FIXTURE	FIXTURE	NO. OF	OPERATION	ELECTRICITY	FIXTURE	FIXTURE	NO. OF	OPERATION	ELECTRICITY	SAVINGS
CONTRACT	TYPE	WATTS	FIXTURES	(hrs/yr)	(kWh/yr)	TYPE	WATTS	FIXTURES	(hrs/yr)	(kWh/yr)	(kWh/yr)
15SZ-120A	2, 4' 34-watt T-12 lamps, mag ballast, under canopy	72	35	4,380	11,038	2, 4' 32-watt T-8 lamps, elect ballast	54	35	4,380	8,278	2,759
15SZ-120A	2, 4' 34-watt T-12 lamps, mag ballast, garages, stairwells	72	582	7,300	305,899	2, 4' 32-watt T-8 lamps, elect ballast	54	582	7,300	229,424	76,475
15QA-110	2, 4' 34-watt T-12 lamps, mag ballast, underground	72	1586	8,760	1,000,322	2, 4' 32-watt T-8 lamps, elect ballast	54	1586	8,760	750,241	250,080
15QA-110	2, 4' 34-watt T-12 lamps, mag ballast, under canopy	72	1814	4,380	572,063	2, 4' 32-watt T-8 lamps, RLO elect ballast	54	1814	4,380	429,047	143,016
15RU-120	2, 4' 34-watt T-12 lamps, mag ballast, underground	72	107	8,760	67,487	2, 4' 32-watt T-8 lamps, elect ballast	54	107	8,760	50,615	16,872
15RU-120	4, 8' 75-watt T-12 lamps, mag ballasts, under canopy	316	5	4,380	6,920	8, 4' 32-watt T-8 lamps, elect ballast, retrofit kit	236	5	4,380	5,168	1,752
15RU-120	4, 8' 75-watt T-12 lamps, mag ballasts, underground	316	39	8,760	107,958	8, 4' 32-watt T-8 lamps, elect ballast, retrofit kit	236	39	8,760	80,627	27,331
TOTAL			4168		2,071,687			4168		1,553,402	**518,285**

Future Impacts

There are many large BART projects underway that are still too early in the planning or design stage to quantify the impact of certain measures within the BFS. While it is difficult to precisely estimate the quantity or volume of resources saved by various measures implemented on these future projects, it is apparent that the BFS will continue to have a large impact. Sustainability practices will play a large role on several projects currently under development at BART.

Specific BFS sections will play a major role on some future BART projects. For example, waste diversion requirements will significantly reduce the impact of the demolition of the Lake Merritt Administration (LMA) Building. In 2002, the LMA was determined to be at risk for becoming severely damaged in a major earthquake and the District determined that it would be most cost effective to dismantle the LMA building. BART's headquarters were relocated and plans began

for the demolition of the LMA. The design to dismantle the building is only approximately 30% complete, however the design involves strategies to dismantle the building slowly and recover valuable structural elements. All materials will be sorted and all steel and concrete will recycled. As much other materials will be recycled as possible as well. Initial engineering estimates project that around 90% of all materials may be salvaged from the project. If this much diversion is achieved, the project will exceed Oakland's local diversion requirement of 70%.

A BART project that will have major sustainability consideration is the ongoing Earthquake Safety Program. This is a $1.3 billion dollar project that will involve seismic upgrades throughout the BART system over the next 10 years. Each phase will involve different construction practices, but in most cases will involve site erosion, sedimentation, noise, storm water, and vibration controls, demolition and debris generation, and concrete use. The impact of all of these elements will reduced relative to standard regulations due to the adoption of sustainability measures within the BFS.

Another important future project is the BART extension to Silicon Valley. This 16 mile extension of the BART system will involve the construction of 6 stations and one future station in Milpitas, 5 miles of subway, and all of the supporting facilities (maintenance yard, intermodal connections, tracks, etc). Because this is a major extension of the entire BART system, it will involve the construction of every facility type and therefore incorporate every sustainability practice built into the BFS.

Lessons Learned during the Sustainable Transit Leadership Project

Developing the BFS requirements to address sustainability under the auspices of this EPA grant provided a number of valuable lessons:

- Partnership with the EPA program manager during the project has allowed for an efficient sharing of project administration and coordination with other agencies and transit experts.

- Collaboration on BFS development and the sharing of project results allowed the grant to influence more than just BART's operations alone. BART has presented to a number of different agencies' representatives and conferences and has shared strategies for and lessons learned by incorporating sustainability in entity-wide standards.

- Sustainability guideline development is applicable and attractive to other sectors outside of transit. For example, the University of Pennsylvania requested information on BART's experience in developing facility standards with sustainability principles to see if a University could learn from and emulate the process applied in transit.

- Specifications in the BFS were applied without modification on a majority of contracts considered. It seemed that changes were only made to BFS sections when the provisions did not apply appropriately to one element or another of a project. For example, the BFS section on paint was modified in a contract for repainting of outdoor substations to

include specifications more appropriate for this particular application – low VOC paint requirements (geared towards indoor environments) were not as important as ensuring the performance of the paint with respect to safety and longevity. There were few other modifications noted in contract specifications and follow up with project engineers would be necessary to understand why modifications were made.

- Measurement of results was difficult because there is no one common source of data across projects, or even resources. Project managers and engineers were generally the best source of information regarding each project, however they often did not have information on project implementation readily accessible (they could produce contracts and drawings, but rarely could produce contractor submittals regarding waste volumes, recycling, etc.). Requiring submittals in the BFS is not enough to properly measure and document project impacts. Enforcement and centralized collection of the project submittals required in the sections on concrete, waste, and erosion (among others) would aid BART managers in understanding and promoting the beneficial impacts of sustainability elements incorporated into the BFS.

- Interviewing project managers and engineers about their projects proved to be a valuable experience for institutionalizing the application of the specifications. For example, some project managers were aware that construction waste diversion was a common practice on BART projects; however they were not aware that the targets set within BFS exceed local requirements. Increased awareness within BART regarding the benefits and magnitude of measures in BFS will help ensure that newer elements within the BFS are enforced.

- The results of the original scope of work have been highly valuable to BART; however the flexibility to expand upon the original objectives after they were achieved allowed the grant to evolve as additional opportunities arose. This allowed the grant to coherently address more widely applicable considerations. The best example of this was a workshop held by BART on transit industry wide guidelines for sustainability that led to the creation of a National Working Group on Sustainability in Transit. This group, which consists of agency architects and directors of engineering from 7 major metropolitan transit agencies, began a draft set of guidelines for adopting sustainability practices that will be broadly applicable across the transit sector. This work has already drawn heavily upon the results of the Sustainable Transit Pilot Leadership Project.